Vehicular to Vehicular (V2V) Communication

Third Year Final Project - PR301

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Vehicular to Vehicular (V2V) Communication   Feb22 - June 22

1) Abstract:

The **Vehicular Communication** project, done under Dr.B.Subbarao with the guidance of Professor Bhargava Rajaram, is aimed at Developing an IoT-5G based Vehicular to Vehicular Communication testbed.
Advancements in Wireless Communications are making it possible for sharing information through communications between vehicles and infrastructure. This has led to applications to increase the safety of automobiles and communication between passengers and the Internet.
In India, it has been observed that **motor crashes have claimed many fatalities**, which is why safety naturally becomes a supreme concern. This calls for an effective methodology to ensure there is a substantial reduction in the number of road accidents. With the inception of the Internet of Things (IoT) and disruptive technologies, vehicles are becoming smarter!
In our project, the aim is to establish seamless communication between neighbouring vehicles for traffic control by deploying the Internet of Things.

This physically implemented V2V communication project incorporates:

Overtaking signalling - That is to establish a signal whether it is safe or unsafe to overtake a physical vehicle present in front of you and overtake accordingly.

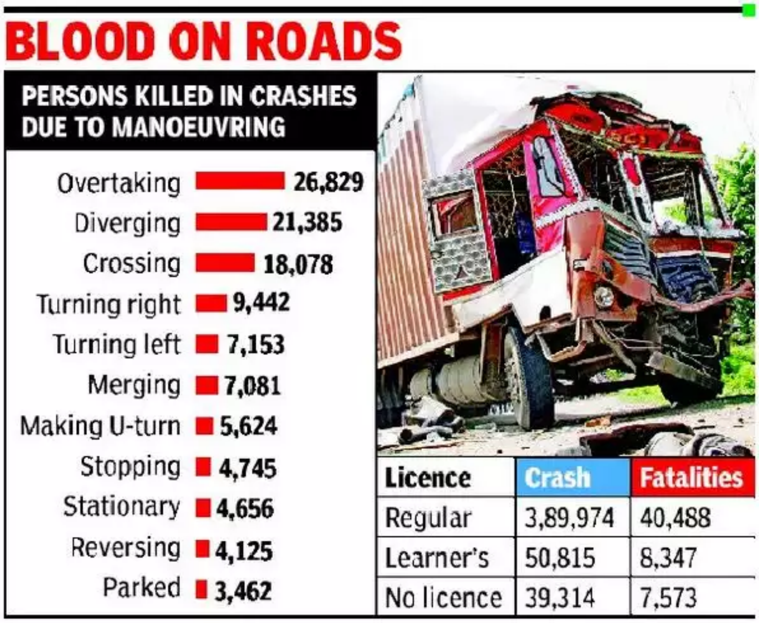
Collision Avoidance - Automatically detect any obstacle (stationary/moving) and dodge it to avoid a collision, by taking a different path.
The implementation was done with the help of real model cars made of components like raspberry pi, ultrasonic sensors, buck converters, motor drivers, etc.
In our testbed, the vehicles were set up in an ad hoc network
After setting up the two model cars in an **adhoc** network, we used **RSSI** (Relative Signal Strength Indicator) in order to develop a method for location estimation.
Finally, calibration was done to find out whether or not it is safe to overtake the neighbouring vehicle or to avoid collision. The concept of this project is an attempt to solve the problem of numerous road accidents across the globe, as the world transitions into a smart environment.

Keywords: **ad hoc network,RSSI**

2) Introduction:

This Vehicle to Vehicle communication project is intended to replicate the real-world simulation of different possibilities of vehicular coordination that we see in our daily lives. The overtaking signalling system that we developed, has the potential of becoming an extremely useful add-on to the modern smart cars, as we can easily determine the oncoming traffic in the other lane and safely overtake the vehicle in front of us, which will in turn reduce the rate of accidents and deaths which are caused due to overtaking on highways and two-lane roads. The main inspiration behind this model that we have developed, is the increased rate of accidents occurring just due to overtaking.

We regarded that it is impossible, that in this technology-driven world, there is no immaculate solution for these collisions. The vehicle-to-vehicle communication project is our best shot at showing how small things when implemented on large scales, will truly make a difference in the present world. According to a report on the country's road accidents and deaths, over 48,000 people died in crashes caused due to overtaking and ‘diverging’ during 2014. “These accidents are also directly linked to speeding. There are two ways to address this concern, either driver must be sensitised or there has to be strict enforcement of traffic laws. Unfortunately, our drivers have no understanding of how to change lanes which also is the main reason for such accidents” said an official transport research wing which has prepared the report after compiling data from local police from across the country. The report also points to how most of the drivers with their licences have little training or knowledge of how to drive safely. It mentions how drivers with valid licences were involved in killing about 40,500 people through analysis of people having licences had revealed how 13% of such licences are other fake or duplicated in India report by National Informatics Centre had found on 7400000 licences out of the total 6 Pro 4GB duplicate once indicating the systematic floors when dawning of such licences.



Licence	Crash	Fatalities
Regular	3,89,974	40,488
Learner's	50,815	8,347
No licence	39,314	7,573

As shown in the statistics above, the majority of the accidents, in India, occur due to overtaking, followed by diverging the lanes. It is a popular fact that the majority of the Indian drivers on the road do not have the patience to actually drive safely and everyone just looks forward to overtaking each other. While in most cases it happens smoothly, there is a high likelihood that a vehicle coming from the other side may collide with the overtaking car.

> According to the latest report on country's road accidents and deaths, over 48,000 people died in crashes caused due to overtaking and 'diverging' during 2014. "These accidents are also directly linked to speeding. There are two ways to address this concern. Either drivers must be sensitized or there has to be strict enforcement of traffic laws.

TOI ARTICLE - Maximum Road accidents occur while overtaking

Hence, we aim to create a network with the help of model cars, which not only automatically turn their direction on detecting an obstacle, but also detect an oncoming car in the opposite lane and stop overtaking accordingly. If the commercial version of this could be implemented in real-life automobiles, this could prevent a lot of accidents and thereby save numerous lives.

3) Problem Definition:

The vehicle to vehicle communication project is aimed at establishing seamless communication between neighbouring vehicles based on certain parameters. **Some of the main questions that our project will be able to answer are:**

- ➢ How safe is it to overtake another vehicle and if it is feasible?
- ➢ How can you avoid obstacles automatically without colliding?
- ➢ How to deploy an Ad-hoc Network and the purpose behind setting up one in this case
- ➢ How to determine the Relative strength between your vehicle and the obstacle?
- ➢ How can traffic management be improved?

4) Background and Related Work:

The main reference materials that we used to get a basic ideology are as follows - (Some had been suggested by our professors and others were extracted from the internet.)

- ★ Vehicular Communication Systems: Enabling Technologies, Applications, and Future Outlook on Intelligent Transportation - IEEE Communications Magazine.
- ★ IEEE 802.11p: Towards an International Standard for Wireless Access in Vehicular Environments - Daniel Jiang, Luca Delgrossi
- ★ Developing a testbed for Intelligent Transportation Systems - Ole Andreas Hansen (NTNU)
- ★ Evolving Wireless Vehicular Communication System level comparison and analysis of 802,11 p, 4G 5G-Muhammad Naeem Tahir; Kari Mäenpää; Timo Sukuvaara, Publisher:IEEE

➢ The Evolving Wireless Vehicular Communication System level comparison and analysis of 802,11 p, 4G 5G was read in order to gauge how it can potentially be scaled up to a 5G testbed. In this paper, comparison of the measurements conducted with IEEE 802.11 p, to the similar measurements with 4G and 5G pilot network, is done.

Majority of the inspiration was taken from the NTNU article, whose aim was to **develop a testbed for intelligent Transportation systems.** The main purpose of this research was to address the area of combining computer simulations with real-world characteristics. They were successful in implementing the following objectives -

- Performing a literature study within the field of ITS.
- Combining research within self-driving cars with small-scale robots.
- Designing a general-purpose testbed prototype for testing ITS applications.
- Performing simulations on the implemented testbed to evaluate its performance.
- Comparing and evaluating the proposed implementation against related solutions.

They have studied the field of ITS deeply, which is **Intelligent Transportation System,** and was basically explained as - *"Systems in which information and communication technologies are applied in the field of road transport, including infrastructure, vehicles, and users, and in traffic management and mobility management, as well as for interfaces with other modes of transportation*".

Vehicular to Vehicular Communication and Vehicular Ad Hoc Networks were clearly explained in the article, which built strong grounds for our understanding.

The components that they used to execute this project were -

- **DiddyBorg V2** - The DiddyBorg robots are one of the most powerful robots available on the market and are easily controlled through a Python API provided by the PiBorg Organisation. It can drive over most indoor and outdoor terrain, can climb inclines up to 45 degrees and perform a 360-degree turn which makes it suitable for a testbed.
- **Raspberry Pi 3** - Raspberry Pi 3 - is a small credit-card-sized computer at a low cost. It can be used as a small personal computer, a media centre or as a controlling unit in an electronics project. It comes with a variety of different Operating Systems which are chosen for different types of uses.
- **ThunderBorg** - ThunderBorg is a powerful dual motor control board which makes it possible to power the DiddyBorg motors and the Raspberry Pi with batteries instead of a USB supply.
- **Camera** - For the robots to have self-driving capabilities, they are fitted with a Raspberry Pi Camera
- **Software Language**.

Although these products are high-end expensive ones with high performance, we used similar tools but simplistic replicated models to fit our budget. (Refer Implementation).

- One of the **Major shortcomings** of this project was the use of a **Digital Compass**. During the pre-project phase, some experiments with a digital compass were performed. Given that the system knows the direction of the robot movement (north, south,west, east), the hypothesis was that the compass could be used to adjust the heading of the robot to match the system heading. So they equipped One of the robots with a 3-Axis Digital Compass and experiments were performed. But after performing a certain number of trials, they have realised that the compass was too affected by the noise coming from the environment. Some calibration techniques were applied to see if the noise could be reduced. But in the end, the conclusion was that a digital compass could not provide enough accuracy for this project.

➢ The Vehicular Communication Systems - IEEE Communications Magazine was more research-based and had a lot of statistical data. It studied deep into the architecture of the automobiles and explained how roadside and onboard equipment communicate with each other.

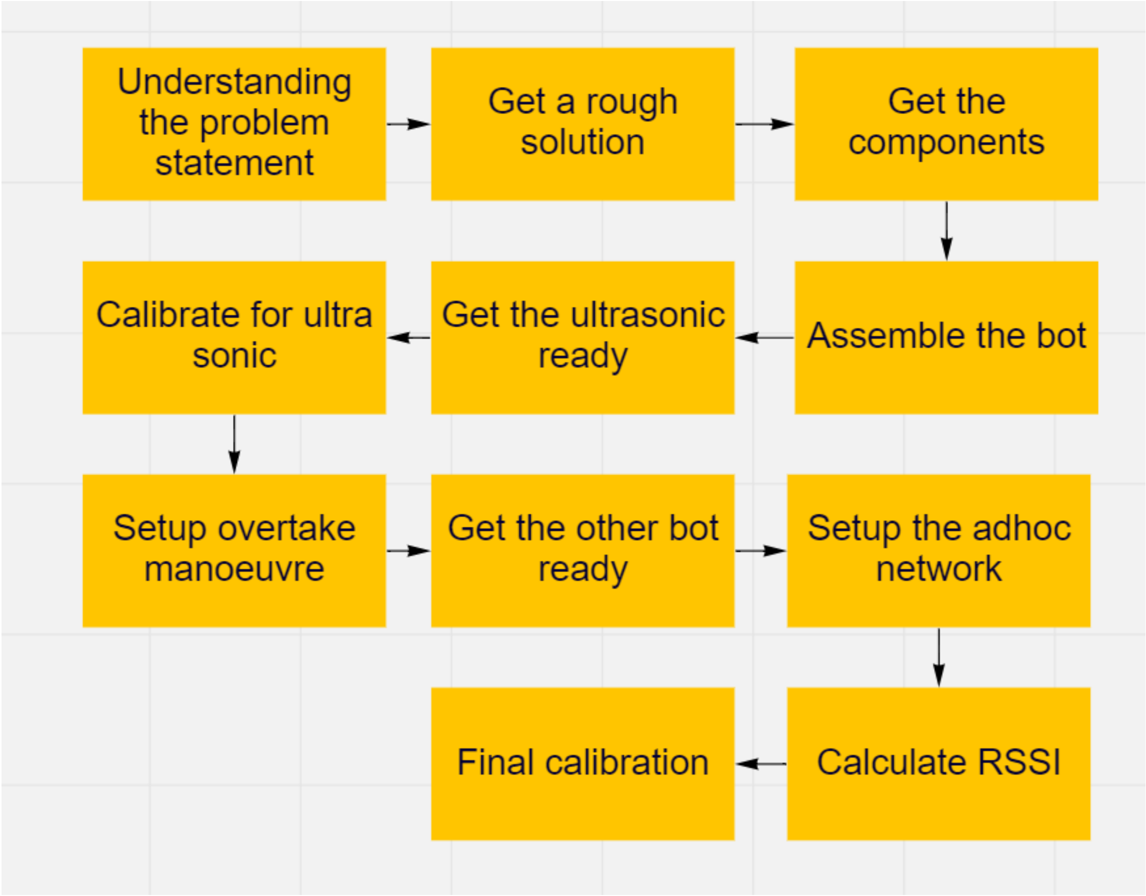
It explained concepts such as -

- WIRELESS DATA LINK
- NETWORKING PROTOCOLS
- IT'S APPLICATIONS
- RELATED CHARACTERISTICS

This report helped us to understand the networking terminologies related to vehicles, VC-enabled applications and their characteristics.

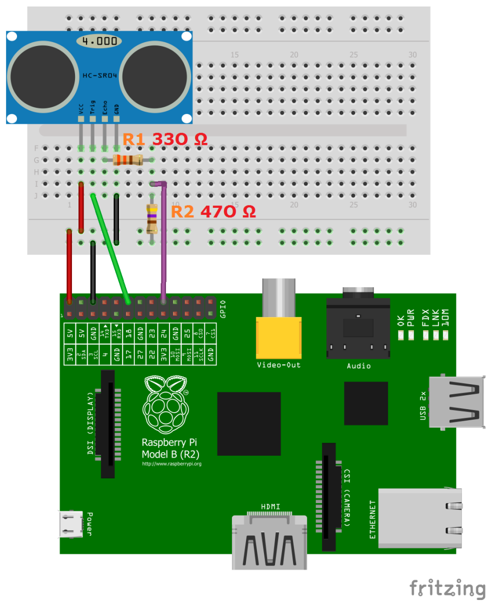
➢ The other two materials mentioned were just used for reference, as to give us an understanding about how the general Vehicular systems worked. They gave us insights about different areas of understanding such as - **Vehicle safety communication** Examples, Dedicated Short Range Communications (DSRC Spectrum Allocation) etc.

5) Implementation [Work done by us] :



- The implementation was done with real model cars, making use of **Raspberry Pi's** which were mounted on each car, to control the parameters like speed and direction of motion. The Raspberry pi was connected to our smartphone through a wi-fi network, to communicate and control the peripherals of the cars by the Raspberry pi, through our smartphone. We were successfully able to control the parameters such as the speed of the vehicle and the direction of rotation of wheels for changing the direction of the Vehicle. The moment of the car was later automated since it has to automatically detect any obstacle and avoid it by itself.

➢ We used **Ultrasonic sensors**, which were mounted on the front part of each car, to measure the distance of any target object by emitting ultrasonic sound waves through it. These sensors provide precise and stable non-contact distance measurements with a range of about 2cm to 4 metres with high accuracy. [*HC-SR04-Ultrasonic Range Finder]*



Ultrasonic Sensor to Raspberry Pi Connections

➢ A **Motor driver** was used on both the cars (one on each), to act as a mediator between the Raspberry Pi and the motors which are connected to the wheels. This basically acts as an interface between the motors and the control circuits. Motors require a high amount of current whereas the controller circuit works on low current signals. So the function of motor drivers is to take a low-current control signal and then turn it into a higher-current signal that can drive a motor. *[Driver chip used: L298 dual H-bridge driver chip]*.

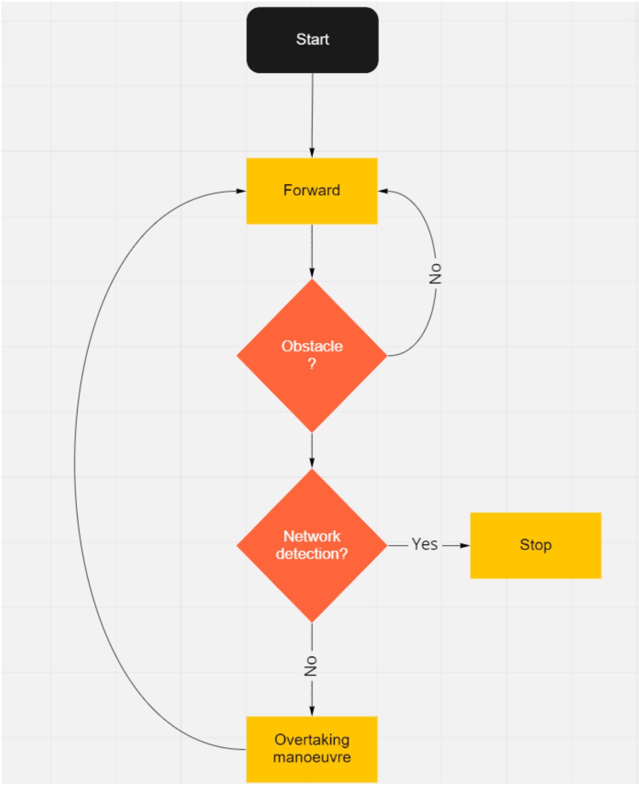
➢ Then we used **Buck Converters** to step down the voltage, from 12V (Batteries) to 5V, which is the required voltage for the Raspberry Pi. *[Serial No of Buck converter : LM2596]*.

- ➢ Additionally, 12V Rechargeable batteries, Wheels, Motors, Mini Breadboards, Resistors (330Ω, 470Ω) were used to make the model car. All the connections are made with the help of Jumper cables. (MM,MF,FF).

With the help of this setup, we were instrumental in communicating with the model cars. Then, in python language, we pushed our code onto the Raspberry Pi to control the vehicle.

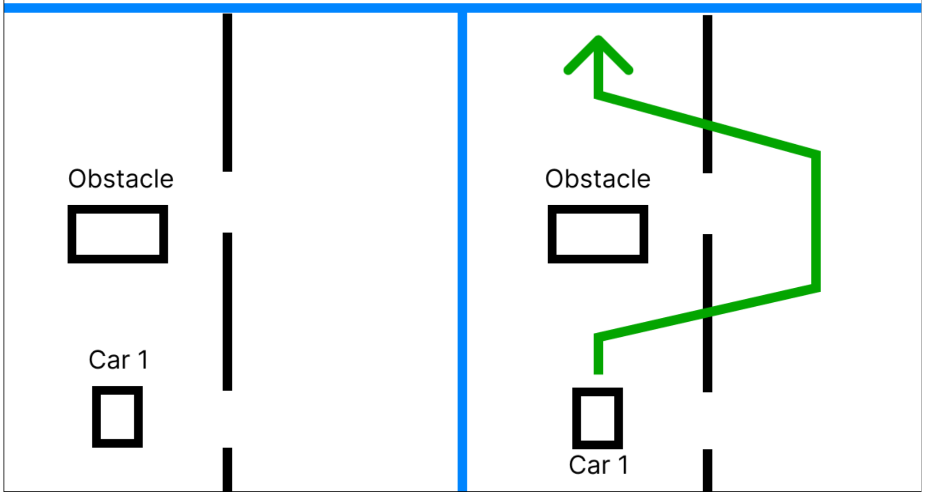
In order to access the command line of the Pi from another computer, we used **SSH**.

The forward function can be inputted through the terminal when ‘w’ is pressed down. Other functions like Left, Right and Back can similarly be called through the terminal by pressing down ‘A’,’D’,and ’S’ keys respectively.

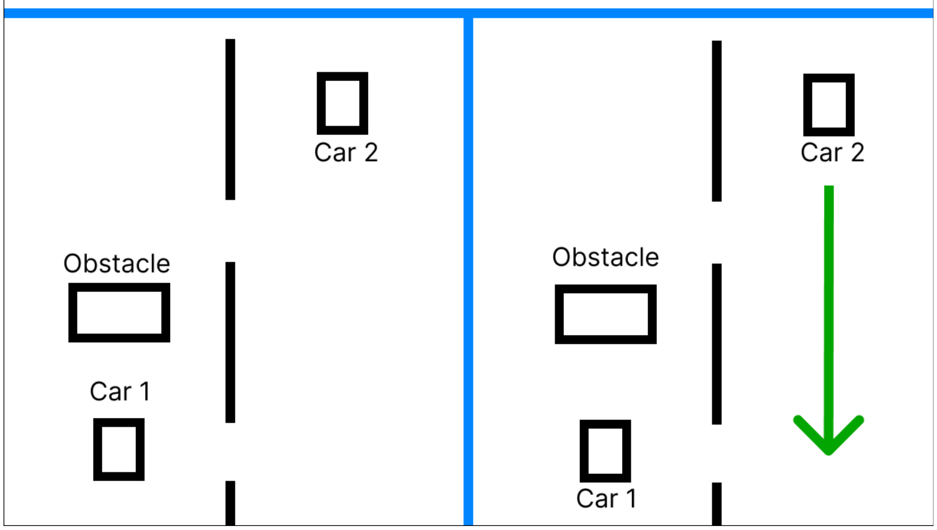


Flow Chart for overtaking system.

Overtaking mechanism after detection of obstacle.



Overwriting overtaking mechanism after detecting car 2



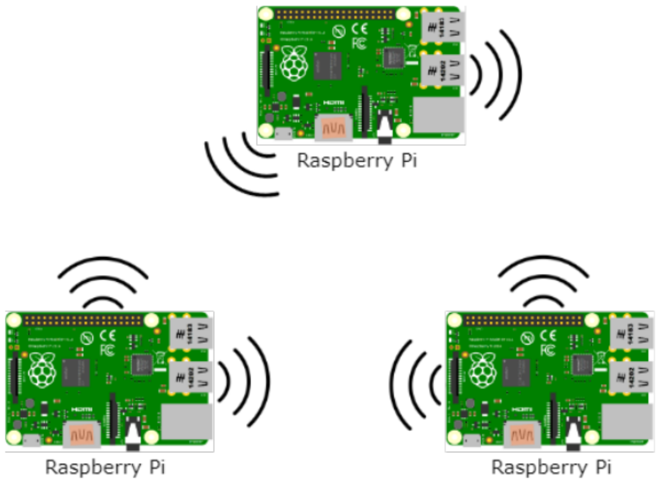
```
def rssi():
    res=spc.check_output("getsi")
    lis=res.split()
    lis2=[]
    for x in range(len(lis)):
        temp=lis[x]
        #print(temp)
        temp=str(temp, 'UTF-8')
        #print (temp)
        lis2.append(temp)
    idx=lis2.index('ESSID:"One"')
    idx=idx-2
    db = lis2[idx].replace('level=-', '')
    db = int(db)
    return db
```

Code for RSSI

```
def loop():
    # first, enable the channel
    pwm=GPIO.PWM(enablePin,110)
    pwm.start(70)
    #GPIO.output(enablePin, 100)

    while True:
        val = input("Enter your value: ")
        print(val)
        dist = distance()
        db = rssi()
        if val == 'w':
            while True:
                fwd()
                dist = distance()
                db = rssi()
                if dist <= 85 and db>50:
                    overtake()
                elif dist<=85 and db<50:
                    stop()
                print('%.1f cm'% dist)
                print(db)

        elif val == 's':
            back()

        elif val == 'a':
            left()

        elif val == 'd':
            right()

        elif val == 'o': # turn 45 and fwd
            pwm.start(80)
            overtake()

        elif val == 'q':
            destroy()

        elif val == 'x':
            stop()
```

Code for Moment of the Vehicle

An **Ad-hoc** was set up in which one model car acted as the host of the Wireless Ad-hoc Network with the name “RPiTest2”. (“**A wireless ad hoc network (WANET) is a decentralised type of local area network (LAN) that is built spontaneously to enable two or more wireless devices to be connected to each other without requiring standard network infrastructure equipment, such as a wireless router or access point”**).



Finally, Calibration was done in order to determine whether it is safe to overtake or not based on the ultrasonic sensor and RSSI readings obtained.

Prototype Images:

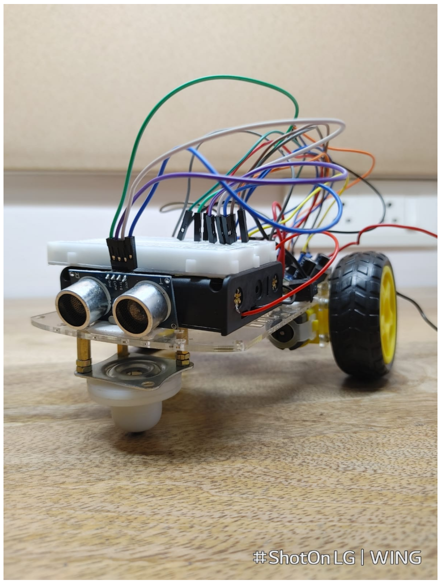


Fig 1 : Isometric View of the Model

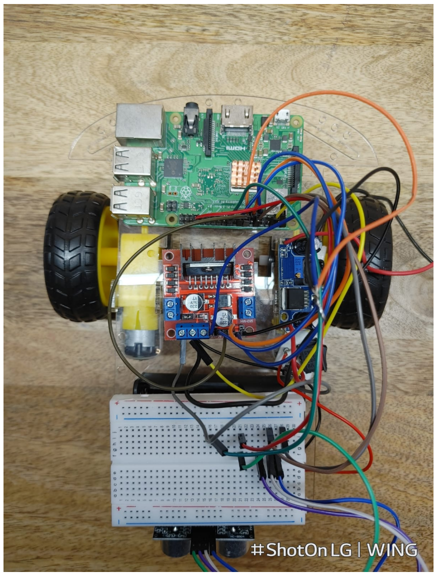
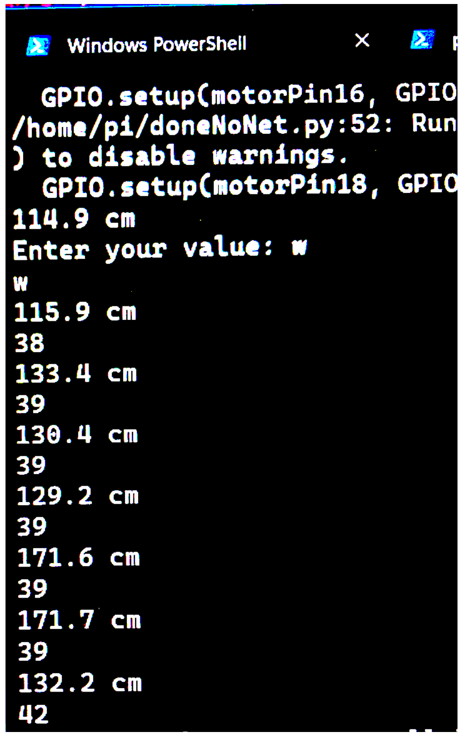


Fig 2 : Top View of the Model

6) Results:

There are majorly two results that we are concerned about:

1. Distance between the mobile object and the stationary object. (Measured with the help of the ultrasonic sensor attached on the vehicle)
2. The Relative Signal Strength Indicator between two vehicles to determine as to how collision can be avoided.



As we can see in the image above, two readings for each iteration are given to us after we run the code. The ultrasonic sensor reading (measured in cm) and the Relative Strength between vehicles (measured in dBm)

In accordance with the threshold limit of the sensor readings described in the code, the vehicle will be instructed to overtake or to stop. Both the scenarios can be demonstrated physically.

7) Conclusion:

Through this project, seamless communication between vehicles was established successfully. This prototype helps in improving traffic management and in increasing fuel efficiency via truck platooning. V2V communication helps drivers avoid traffic snarl-ups and to maintain a safe, sensible distance from the other vehicles. Beyond that, the technology can also be utilised to ensure safe parking of vehicles and also lane-keeping, helping drivers in avoiding unsafe drifts.With V2V communication technology, road accidents can be minimised by roughly 70-80%. In short, Vehicle to vehicle communication systems can save lives and enhance driving efficiency. Having said that, there are risks associated with such a setup as well. (Hacked system, which could result in the car doors locking up, the engine passing the speed limit, etc.) If such risks can be addressed, frequency planning can be done, this work can potentially be scaled up to a 5G-IoT testbed.

8) Links : For the full length code implementation, please refer to the following link:

https://github.com/Rahul-05/Vehicle-to-vehicle-V2V

9) References :

The list of references used for this project and link to the code is given below:

1. Vehicular Communication Systems: Enabling Technologies, Applications, and Future Outlook on Intelligent Transportation - IEEE Communications Magazine.
2. IEEE 802.11p: Towards an International Standard for Wireless Access in Vehicular Environments - Daniel Jiang, Luca Delgrossi
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